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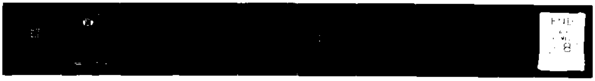

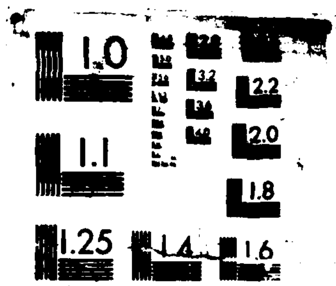

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ADVANCED DISPLAY SYSTEM
THE SINGLE CRYSTAL-CATHODE
RAY TUBE (SC-CRT) STEREOVIEWER

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BIOGRAPHICAL SKETCH

Donald M. Camp received his B.S. degree in Oceanography from George Washington University in 1978 and has completed graduate coursework in Marine Science/Remote Sensing at the University of Delaware. He is currently a Senior Project Engineer with the U.S. Army Engineer Topographic Laboratories (USAETL) involved with computer image generation, optical disc technology and stereoscopic viewing systems.

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ABSTRACT

This paper describes a new generation softcopy stereo display system developed by the Topographic Developments Laboratory of the U.S. Army Engineer Topographic Laboratories (USAETL) utilizing a Bell Laboratories proprietary technology, the Single Crystal Cathode Ray Tube (SC-CRT). The two three-inch SC-CRTs give the stereoviewer very high resolution and illuminance, while providing a compact display that does not experience the degradation of quality and brightness over time that is typical of conventional CRTs. This development represents a significant advance in the state of the art over conventional powdered phosphor CRTs, and presents new opportunities to utilize softcopy stereo displays in areas traditionally dependent on photographic quality source imagery.

INTRODUCTION

Traditional image exploitation techniques take advantage of the very high resolution and storage density inherent in photographic film, as well as the highly refined optical/mechanical instrumentation that has developed around particular exploitation tasks. For example,

variable magnification and precise film positioning enable a wide range of tasks to be performed with a single stereopair, ranging from coarse visual screening and large area search, to precise target positioning and analytical elevation extraction.

Recently, however, there has been an increasing demand for digital products from manual image exploitation tasks. Elevation and feature extraction, terrain intelligence and point positioning data are now required in digital form as inputs to a variety of information systems. There is also a recognition that digital image enhancement techniques and interactive automated processing can provide a new set of tools to augment the analysis tasks. The conversion to a digital processing environment is already taking place in many of the larger mapping establishments and research labs, and will undoubtedly become more widespread as computer costs continue to decline.

CURRENT DISPLAY TECHNOLOGY

One of the primary deficiencies seen in current digital image analysis systems is in the display subsystem, which provides the critical operator interface to the processing system. These image displays rely on very mature CRT technology which has only seen marginal improvements when compared to the processing capabilities of the systems that drive them. In the many analysis tasks where stereo viewing is required for mensuration and feature delineation, the deficiencies of the operator interface tend to multiply. Thus, the design of a softcopy stereoscopic display device must account for the physiological and human engineering aspects as well as the requirement to display images with sufficient fidelity for the intended exploitation task.

Stereo Displays

There are a variety of approaches taken in the current state-of-the-art in softcopy stereo displays, each with its advantages and drawbacks. Most of the existing systems are prototypes or in limited production, due to the specific requirements of particular applications.

Anaglyphic displays are perhaps the most common, due to the low cost (only one color monitor is needed) and the ease of set up. Another advantage of this approach is that geometric distortions in the CRT (typically 3%) affect both the left and right image equally. However, these displays do not permit color images to be viewed, and only achieve marginal seperation of the stereo images. Chromatic aberration of the eye (due to the difference in refractive index of the two dominant wavelengths) may cause discomfort with extended viewing, and may also create errors in mensuration.

Shuttering liquid crystal and PLZT devices can also provide stereo displays using only one CRT, by interlac-

ing the left and right images on alternate lines of the raster scan pattern. Two versions of this type of mechanism are currently available - one in which the left/right shuttering screens are worn as goggles by the operator, and the other in which a shutter/polarizing filter is placed directly in front of the screen, allowing the observer to wear a simple set of polarizing filters over the eyes. Some of the drawbacks of this approach are that resolution in the vertical dimension is halved, brightness of the display is diminished by the many filter and shutter surfaces, and size is limited by the available liquid crystal devices.

Binocular systems allow color viewing, and full resolution display if two monitors are used. Alternatively, a single monitor may be used with a split screen display that provides one half resolution in the horizontal dimension. These approaches require a large and cumbersome optical hood custom made for the displays. The split screen approach also introduces errors due to the variable barrel distortion of the screen, which affects the left and right halves in different amounts. Binocular systems also have disadvantages common to traditional photo based stereo viewers, in that head movement is severely restricted, and set up procedures are required for each individual using the system.

The quality baseline against which softcopy stereo displays are ultimately evaluated is usually the hardcopy imagery counterpart. Sufficient resolution and field of view are needed for an image analyst or photogrammetrist to perform tasks and extract the desired information, such as feature delineation or point positioning, efficiently. The actual display resolution required is subjective, however, in that digital pan and zoom can compensate for some display limitations, provided the source material has a sufficient level of detail. Given the large disparity between photographic and current electronic display resolution, it seems likely that analysts will continue to demand higher resolution displays as they become available.

CRT Technology

The major components of a conventional CRT are depicted in a simplified manner in Figure 1. They consist of the vacuum envelope, the electron gun with its associated focusing mechanism and deflection yoke, and the phosphor target or screen. The phosphor target is composed of chemical elements and compounds which emit light (photons) when struck by electrons from the gun. In a standard CRT, the phosphor material is deposited on the faceplate of the vacuum envelope by the settling of particulates out of a liquid, creating a rather coarsely textured coating. The phosphor layer is then coated with aluminum, which is transparent to electrons, but serves to establish the anode potential and drains the deposited charge (Bell Labs, 1986).

In operation, a beam of electrons is generated by the electron gun and focused to form a spot on the phosphor screen. The amount of light emitted by the phosphor is determined by the number and energy of the electrons. The energy of the electrons is established by the anode potential (the voltage applied between the electron gun and the aluminum surface of the screen). The number of electrons establishes the beam current, which is typically varied to change the intensity of the light emitted from each spot on the screen.

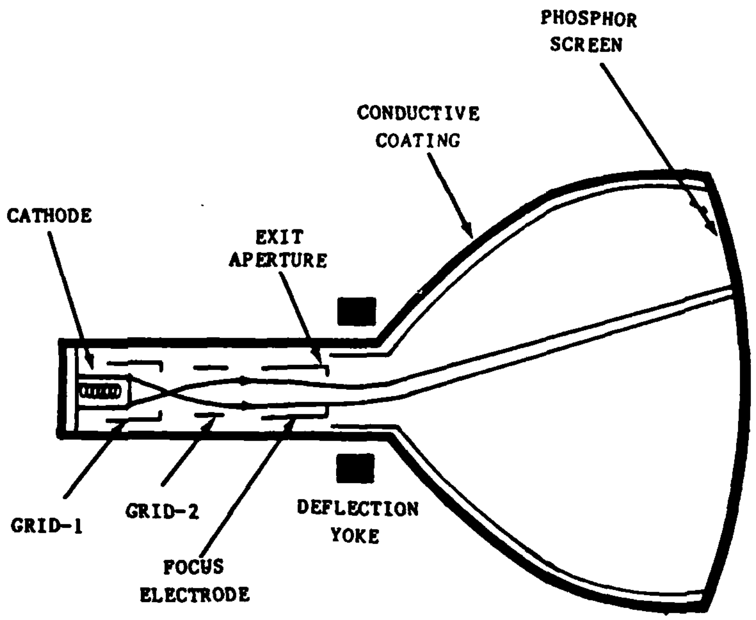

Figure 1. Components of a conventional Cathode Ray Tube.

Bell Laboratories' Single Crystal CRT

Many of the inherent limitations of current CRT technology - specifically, resolution, luminous intensity, contrast, uniformity and lifetime - are imposed by the particulate nature of the phosphor coated screen. These limitations have largely been overcome by the development of the Single Crystal CRT (Bell Labs, 1986).

The SC-CRT is essentially a small (up to 3") conventional CRT having its particulate phosphor coated faceplate replaced by a flat, transparent, single-crystalline phosphor faceplate. The new faceplate actually consists of a single crystal of Yttrium-Aluminum-Garnet (YAG), which has a second, phosphor doped YAG layer atomically bonded to it. The result is a material which is free of

structure at the wavelength of visible light, thus exhibiting no internal scattering. This translates to a CRT with resolution limited only by the electron optics. Prototype SC-CRTs have demonstrated the capability of 4000 line per inch resolution. One of the attractive features of this is that, with appropriate magnification systems, a stereo display device can be made small and rugged enough to fit in fielded shelters and vans without sacrificing resolution.

SC-CRTs have several other properties which make them ideally suited to image display applications. The high thermal conductivity of the YAG faceplate allows very high input power densities (i.e. very bright displays) without burning the phosphor material, and without any measurable coulombic degradation over time. This is shown graphically in Figure 2.

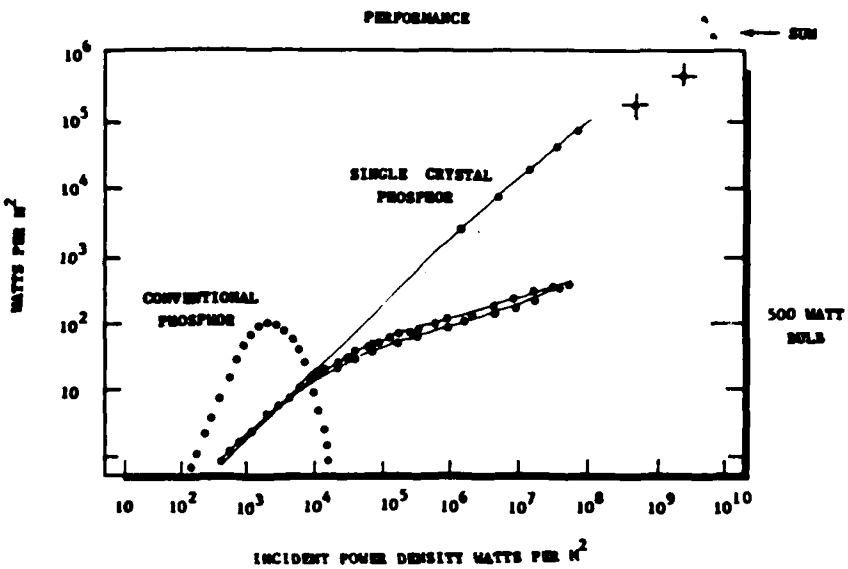

Figure 2. Performance comparison of conventional phosphor CRT with Single-Crystal CRT.

The drawbacks of the current prototype SC-CRTs include their monochrome limitation, although a variety of colors including white are available, and the small size.

ETL STEREO DISPLAY SYSTEM OVERVIEW

The SC-CRT stereo display consists of two "PC" sized modules: one housing the large exit pupil optics and the two SC-CRTs; and one housing the drive electronics.

The display sytem was specified to accept a variety of input signals for use in a research and testing environment. Typically, the digitized stereo pair is supplied over two of the color channels of an RGB output device. The system is capable of displaying 512 X 512 to over 1K X 1K images. Thus far, it has been successfully interfaced to a 512 line VICOM image processing system and a 1024 X 1280 Symbolics AI workstation for demonstrations. It should be noted that the resolution of the prototype display is limited by the drive electronics, the optical components and the host image processing systems. With the development of new support elements, the display should be capable of better than 2K X 2K resolution.

Optics

The stereoviewer optics, originally fabricated for another system, consist of two pairs of rectangular magnifiers that provide a large aperature viewing window. Mirrors are used to separate the optical path and provide sufficient space for the SC-CRTs. The digital three-dimensional image can be viewed from 0.5" to several feet from the optical face. This large exit pupil capability allows substantial head and eye movement, thus increasing the comfort of the analyst. The optics can accommodate normal interpupilary distances between 55 and 75 mm without making any adjustments. The apparent image distance from the exit pupil is approximately 18.5", with the two CRTs appearing as a 7.4 inch square display.

SC-CRTs

Two 3" white phosphor YAG tubes are mounted with the optical assembly, yokes and focusing coils in the stereoviewing unit. The stereo viewing unit is tethered to the electronics compartment, which contains modified Tektronix 634 CRT drivers and associated electronics. The yokes, focusing coils, sync separator and yoke driver boards were modified or replaced to meet the SC-CRT requirements. No special shielding was required for X-Ray emanations.

SUMMARY

A promising new CRT technology has been developed by Bell Laboratories, which eliminates many of the previous shortcomings of conventional display tubes. Two of the white phosphor SC-CRTs were integrated in a compact, operator friendly stereo display device under an ETL contract, in order to demonstrate the capabilities of this technology. The system has been interfaced to image display systems of various resolution for demonstration purposes. Further testing and evaluation of the display is planned in the coming year.

ACKNOWLEDGEMENT

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